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**Status Report**

# Development of a Concept for High Power Beam Dumps and Catchers, and the Pre-separator Area Layout for Fragment Separators for RIA

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The goal of this project is to develop and analyze design concepts for high power beam dumps and fragment catchers and for the layout of the preseparator for the fragment separators for RIA. Key criteria for this work include consideration that a maximum beam power capability of 400 kW of heavy ions including those of uranium should be achievable for these components. Therefore, high priority is being given to both the conceptual design development and materials studies for components having these power handling capabilities in addition to concepts for remote handling/maintenance that may be required for radiation damaged and activated dumps, catchers, separator magnets and other components. Such a study is necessary for a more realistic overall concept of the accelerator facility design where conventional facility, remote handling, radiation safety, and nuclear facility are integrated. The project is carried out in collaboration between MSU, ORNL, LLNL and LBNL and involves experts in rare isotope beam production, high- power targets, magnet design, fragment separator design and operation, radiation characterization and radioprotection, facility classification, remote handling, and material studies.

**Organization of the collaborative effort and recruiting**

Efficient and frequent communication within the collaboration was regarded to be of particular importance for such a complex project involving experts at different places. For this purpose video and data conferences are being held on a biweekly basis for the presentation, discussion, and planning of the ongoing work. A server for document exchange and a webpage have been setup, where all presentations and the minutes of the meetings are posted. In addition to the biweekly videoconferences a 2-day working meeting simulations workshops were organized (see below). Planning of the work started already prior to the receipt of funding via regular videoconferences and during a visit of a MSU delegation to ORNL/SNS to discuss remote handling issues.

A postdoctoral researcher (Valentin Blideanu) experienced in radiation transport calculations was hired at MSU. He started August 20 and works 50% on this proposal and 50% on the proposal on the “Development of a Concept for ISOL Area at RIA”. He will carry out radiation transport calculations for both areas.

**Progress to date relative to the objectives outlined in the current R&D proposal**

The goals for Year 1 of this multi-year effort are to study the important aspects of the target and pre-separator layout, to make pre-conceptual designs for the most critical items including the beam dumps and fragment catchers, to characterize the radiation environment in the pre-separator and its impact on the

RIA facility, and to identify further R&D needs. Work has started on most of the topics outlined in the proposal and first results have already been achieved which are used as input in the iterative process required to develop a viable concept for the fragmentation target area and preseparator area.

The functional requirements for the fragment separators for RIA have been defined by MSU with input from ORNL and LLNL. Two separators will be necessary, one having high acceptance to deliver fragments to a gas catching station, and one having high resolution, to deliver fragments to a high-energy experimental area. Since RIA can be expected to run in campaigns with heavy ion beams for fragment production alternating with light-ion beams delivered to ISOL target areas it is necessary to ensure a continuous operation of the separator systems and, if possible, even a parallel operation of both stations. Desirable beam dump and catcher lifetimes are 2 weeks minimum and preferable 1-2 month. In order to ensure continuous operation target change and commission times of less than 2 weeks are therefore required. This requirement will be used as a basis for developing the remote concept.

Third-order layouts for options for the fragmentation target and preseparator areas have been prepared by MSU for review and discussion by the collaboration. A first analysis of beam-fragment optics, charges states and power densities for representative heavy ion beams and fragments delivered to the beam dump has been completed at MSU. Dimensions of the dump and beam spot sizes have been computed based on the preseparator concept.

Led by LLNL, a static water-cooled wedge beam dump that can meet requirements for the available beam powers and power densities has been conceptually designed. The issue of beam sputtering was identified and calculations were carried out and found to be not a significant issue. Issues of radiation damage and dump lifetime are currently being investigated. Preliminary radiation damage simulations using the heavy ion transport code PHITS calculations show significant damage (in terms of displacements per atom) in the vicinity of the Bragg peak of uranium ions. The significance of this very localized damage will be investigated. We are consulting with radiation damage experts from UC-Berkeley and ORNL on this topic, and to ensure we are estimating all-important contributions to radiation damage by heavy ions. In addition to the static dump concept, non-static dump concepts are also being developed and reviewed by the collaboration. These are to ensure longer lifetimes however they necessitate needs for more complicated remote handling, moving seals and bearings, and in one concept, a beam window and liquid metal beam stop/coolant.

MSU has defined preseparator layout space constraints, and they and ORNL collaborators have developed 3D drawings of the target/preseparator area in preparation for a more detailed analysis of the remote handling requirements. ANL personnel that have constructed a prototype liquid lithium target were consulted to provide information about its layout (electrical and vacuum services, heat exchanger system etc.) that impact our collaboration's identification of remote handling requirements. ANL personnel have recently joined our biweekly videoconference series to this end.

A first 3D layout has been made for the fragmentation target station having a liquid lithium target concept, using the vertical modular concept for the target and the beam dump as developed for the ISOL target stations. A 3D drawing of the entire fragment separator area was prepared taking preliminary shielding calculations into account. First radiation transport calculations using the heavy ion transport code PHITS are now being carried out to for a more detailed analysis of the remote handling requirements.

The collaboration has identified the need for assuring quality calculations of radiation environments and effects, to assure quality calculational benchmarks, and compare heavy ion transport computational tools against those benchmarks. Heavy ion transport codes necessary for this are in their infancy. To this end, LLNL hosted a code workshop led by Koji Niita, the author of PHITS, and MSU hosted a mini-course by the author of the mature transport code MARS, Nikolai Mokhov. PHITS and the light-ion-transport version of MARS are now running at MSU and LLNL. Within a month it is expected that the heavy ion version of MARS will be released. It will be used in these R&D efforts and those in our companion proposal on ISOL target stations. Mokhov is performing a calculation similar to the one using PHITS that identified the large radiation damage in the beam dump. The results from the two codes will be compared. In addition, the collaboration has identified that data are needed for radiation damage done by heavy ions, and are presently discussing experiments to provide suitable data, which could be done at MSU.

The application of facility segmentation to determine the boundaries of the nuclear facility, with emphasis on the LINAC-to-target interface, the target-to-presparator, and preseparator-to-separator interfaces has been discussed by the collaboration. No specific work has been carried out so far on these topics. This task will be taken up as soon as more realistic information on radiation levels and inventory is available. However, a thin window between the preseparator and separator areas is felt necessary for facility segmentation purposes and is currently included in our designs.

**Out-year Work Plan**

The work after one year will be refined into one-to-two years following.

Develop improved, more detailed concepts for beam dumps, catchers and pre-separator layouts based on the work plan of Year 1, for engineering considerations.

Analyze radiation levels in detail from improved devices, checking impacts on civil construction, environmental protection, facility hazard classification, remote handling and material decisions.

Develop mockups or prototypes of devices for testing.

Work on R&D issues identified in Year 1.

**Estimate of time needed to complete your R&D goals**

We are confident to be able to complete a first iteration on the development for a concept for the fragment target and preseparator areas at a level that allows us to identify those areas where more detailed work is required. In the following year the work will concentrate on improved, more detailed concepts for those areas, components and remote handling at a level that can be used for engineering considerations. The most critical remote handling scenarios are planned to be tested with mockups and material studies will be carried out as far as required. Provided that similar funding is available, the effort for completing a realistic concept for the areas is not expected be more than two additional years.

**Summary of expenditures to date**

| | Funds received | Personnel | Travel | Other |
|---|---|---|---|---|
| MSU | $137k (15 June 2004) | $18,070 | $1,920 | $3,020 |
| LLNL | $195k (June, 2004) | $30k | 0 | 0 |
| ORNL | $210k (June, 2004) | $44,206 | $2,667 | 0 |
| LBNL | $8k (May, 2004) | $8,000 | 0 | 0 |